AN 127:59268 HCA
TI **Composite solder** material with prevention of void generation for bonding semiconductor device
IN Kogashiwa, Toshinori
PA Tanaka Electronics Industry Co., Japan
SO Jpn. Kokai Tokkyo Koho, 7 pp.
CODEN: JKXXAF
DT Patent
LA Japanese
FAN.CNT 1

	PATENT NO.	KIND	DATE	APPLICATION NO.	DATE
PI	JP 09122967	A2	19970513	JP 1995-277479	19951025

AB The **solder** material comprises 0.01-1.0 vol.% of an **intermetallic** compd. grain of av. grain size 1-30.mu.m.

AN 127:84578 HCA
TI Issues regarding microstructural coarsening due to aging of eutectic tin-silver **solder**
AU Gibson, A.W.; Choi, S.L.; Subramanian, K.N.; **Bieler, T.R.**
CS Department of Materials Science and Mechanics, Michigan State University, East Lansing, MI, 48824-1226, USA
SO Des. Reliab. Solders Solder Interconnect., Proc. Symp. (1997), 97-103. Editor(s): Mahidhara, Rao K. Publisher: Minerals, Metals & Materials Society, Warrendale, Pa.
CODEN: 64QHAZ
DT Conference
LA English
AB Pending Federal regulations, environmental concerns, and alternate m.p.. **solders** provide the impetus for using Pb-free **solders**. Automotive electronics and **solders** are exposed to extreme thermal cycling at -40-+150.degree. under cyclic and quasi-static conditions [1]. and they experience low and high frequency mech. fatigue vibrations. Since coarsening of microstructural features is known to affect fatigue resistance, the aging behavior is studied using eutectic Sn-Ag **solder** as a model system, with and without 20 V% of a Cu6Sn5 **intermetallic** composite strengthening phase. The composite **solder** was developed to det. whether the microstructure could be stabilized to prevent coarsening. For comparative purposes, a composite **solder** was also made using eutectic Sn-Pb as the matrix. Small single shear lap specimens with a size similar to joints in microelectronic applications are used to obtain microstructures that result in real **solder** joints. Eutectic Sn-Ag **solder** joint microstructures coarsen when aged at +60-+150.degree. for as little as 100 h. The microstructural evolution is monitored with aging temp. and time, and the kinetics of aging is detd. The effects of adding composite **intermetallic** phases on the aging behavior are compared to the model Sn-Ag system. The effect of cyclic aging vs. static aging is studied in the Sn-Ag/Cu6Sn5 and Sn-Pb/Cu6Sn5 composite **solders**.

AN 127:198232 HCA
TI Activation energies of **intermetallic** growth of **Sn-Ag** eutectic **solder** on **copper** substrates
AU Flanders, D. R.; Jacobs, E. G.; Pinizzotto, R. F.
CS Materials Sci. Dep., Univ. North Texas, Denton, TX, 76203-0308, USA
SO J. Electron. Mater. (1997), 26(7), 883-887
CODEN: JECMA5; ISSN: 0361-5235
PB Minerals, Metals & Materials Society
DT Journal
LA English
AB **Intermetallic** phases formed along a **Sn-Ag** eutectic **solder/Cu** interface during solid-state aging were characterized and the activation energies of Cu3Sn and Cu6Sn5 growth were calcd. Diffusion couples consisting of **Cu**/96.5Sn-3.5 **Ag/Cu** were aged at 110 to 208.degree. for 0. to 32 days. After aging, the **Cu/solder** interfaces were examd. using SEM and energy dispersive x-ray spectroscopy. The growth rate consts. for each **intermetallic** layer were calcd. assuming simple parabolic diffusion-controlled growth model. The activation energy for Cu3Sn growth is 0.73 eV/atom and the activation energy for Cu6Sn5 growth is 1.11 eV/atom.

AN 123:63014 HCA
TI Evolution of eutectic SnAg, SnBi and SnPb joint and bulk microstructures
AU Raeder, C. H.; Mitlin, D.; Yang, W.
CS Design and Manufacturing Institute, R.P.I., Troy, NY, 12180, USA
SO Int. SAMPE Electron. Conf. (1994), 7(Critical Materials and Processes in a Changing World), 355-65
CODEN: ISECE8; ISSN: 1051-1067
DT Journal
LA English
AB **Sn**-37 wt.% Pb eutectic is presently the most commonly used alloy for electronics **soldering**; **Sn**-58 wt.% Bi and **Sn**-3.4 wt.% **Ag** are eutectic alloys which might be used in addn. to or in place of SnPb to cope with increasing electronic packaging complexity and E.P.A. legislation. This study explores the effects of aging on the evolution of eutectic SnAg, SnBi, and SnPb microstructures. SnAg **solder** joints were aged up to 12 days at temps. up to 190.degree.C. Microstructural changes consisted of Ag3Sn **intermetallic** coarsening, Cu6Sn5 **intermetallic** dendrite coarsening in the bulk **solder**, and Cu6Sn5 and Cu3Sn layer growth at the **Cu/solder** interface. Cu3Sn growth is found only above 140.degree.C. **Sn**-Bi **solder** joints were aged from 3 to 50 days at 80.degree.C. The aging expts. reveal segregation of the Bi-rich phase of the **solder** to the **intermetallic/solder** interface, Cu6Sn5 **intermetallic** growth at the **Cu/solder** interface and interphase coarsening. Bulk samples of the high vol. fraction SnBi and SnPb eutectics were aged at 40, 90, and 120.degree.C to quantify interphase coarsening. SnBi coarsens more rapidly than SnPb at a given temp.

AN 119:144359 HCA
TI The formation and growth of **intermetallics** in composite **solder**
AU Wu, Yujing; Sees, Jennifer A.; Pouraghabagher, Cyrus; Foster, L. Ann; Marshall, James L.; Jacobs, Elizabeth G.; Pinizzotto, Russell F.
CS Cent. Mater. Charact., Univ. North Texas, Denton, TX, 76203, USA
SO J. Electron. Mater. (1993), 22(7), 769-7
CODEN: JECMA5; ISSN: 0361-5235
DT Journal
LA English
AB The formation and growth of **intermetallic** compds. at the **solder**/substrate interface are factors affecting the **solderability** and reliability of electronic **solder** joints. To study the diffusion behavior and microstructural evolution of **Cu**-**Sn** **intermetallic** compds. at the composite **solder**/**Cu** substrate interface, the eutectic **Sn** -37% Pb **solder** and **solder** composites contg. particle addns. of **Cu**, Cu3Sn, Cu6Sn5, **Ag**, Au, and Ni were used. Annealing temps. of 110-160.degree. were used with aging times of .ltoreq.64 days. The **Cu**-contg. composite **solders** generally formed thinner Cu6Sn5 layers, but thicker Cu3Sn layers than were formed by the eutectic **solder** alone. These **Cu**-contg. addns., therefore, resulted in increased activation energies for Cu6Sn5 formation and decreased activation energies for Cu3Sn formation compared to those of the eutectic **solder**. The activation energy for Cu3Sn formation decreased relative to that of the eutectic **solder** for **Ag** and Au composite **solders**, even though less Cu3Sn was formed at the substrate interface. Ni drastically reduced the Cu3Sn thickness and increased the Cu6Sn5 thickness. However, the Cu6Sn5 contained a substantial vol. fraction of voids close to the **Cu** substrate. Two mechanisms to explain the effects of the **Cu** -contg. and **Ag** particles on the kinetics of **intermetallic** formation were proposed. First, the particles act as **Sn** sinks which remove **Sn** from the **solder** and decrease the amt. of **Sn** available for reaction at the **solder**/substrate interface. Second, the particles reduce the cross-sectional area available for **Sn** diffusion, which also reduces the amt. of **Sn** available at the interface for reaction.

AN 127:84587 HCA
TI Mechanical properties of Sn-Ag composite **solder** joints containing copper-based **intermetallics**
AU Choi, S.L.; Gibson, A. W.; Mcdougall, J.L.; **Bieler, T.R.**; Subramanian, K.N.
CS Department of Materials Science and Mechanics, Michigan State University, East Lansing, MI, 48824-1226, USA
SO Des. Reliab. Solders Solder Interconnect., Proc. Symp. (1997), 241-245. Editor(s): Mahidhara, Rao K. Publisher: Minerals, Metals & Materials Society, Warrendale, Pa.
CODEN: 64QHAZ
DT Conference
LA English
AB Differential thermal expansion in electronic systems induce stresses resulting in substantial cyclic deformation of **solder** joints, which leads to eventual fracture. While fatigue deformation is a major concern for electronic **solders**, creep constitutes an important component of deformation since stress relaxation occurs after a temp. change. In realistic thermal cycles there is sufficient time for stress relaxation processes to occur, and creep induced damage may result. Small single shear lap joint specimens were made to simulate realistic **solder** joints. By aging these specimens at different temps., several variations in microstructure were obtained. In an effort to modify creep strength of a model Sn-Ag lead-free **solder**, copper based **intermetallics** were introduced into the **solder**. **Solder** joints were deformed in creep conditions at room temp., and after some steady state creep strain, load changes were made to facilitate the evaluation of the stress dependence of strain-rate and to reduce the no. of test specimens. Comparisons between unaged and aged specimens, and between non-composite and composite **solders**, were performed. The anal. of fracture surface of crept **solder** joints was performed with SEM.

AN 131:231895 HCA
TI Effect of Au coating on the wettability of **Cu** substrate by **Sn-Ag** eutectic **solder**
AU Takao, Hisaaki; Hasegawa, Hideo
CS TOYOTA CENTRAL R & D LABS., INC., Nagakute, Aichi, 480-1192, Japan
SO Nippon Kinzoku Gakkaishi (1999), 63(5), 565-568
CODEN: NIKGAV; ISSN: 0021-4876
PB Nippon Kinzoku Gakkai
DT Journal
LA Japanese
AB The influence of thin coating of Au (70 nm) on the wettability of the **Cu** substrate by **Sn-Ag** eutectic **solder** (**Sn**-3.5Ag, wt.%) was investigated, using a meniscograph testing machine equipped with a contact angle measuring system. Wettability of **Cu** by liq. **Sn**-3.5Ag was improved by the Au coating, esp. in contact angles. Namely, the contact angle was reduced to 29-30.degree. on the Au-coated **Cu** from 42-45.degree. on the uncoated **Cu**. On the Au-coated **Cu**, Au layers remained on unwetted areas, while it dissolved into **solder** on wetted areas, followed by the formation of a **Cu-Sn intermetallic** compd. as seen on the uncoated **Cu**. The improvement in the wettability by the Au coating on the **Cu** substrate would be caused by the difference of substrate-flux interfacial tensions (.gamma.sf). On the other hand, the wettability of the Au substrate by liq. **Sn**-3.5Ag with the contact angle of 60-64.degree. was inferior to that of the Au-coated **Cu**. At the **solder** -Au substrate interface, Au-**Sn intermetallic** compds. were formed, which were not formed on the Au-coated **Cu** substrate. Consequently, the difference of the wettability between Au and Au-coated **Cu** is attributed to the difference of substrate-liq. **solder** interfacial tensions (.gamma.sl). These results suggest that it is necessary for the Au layer to be thin so as not to form Au-**Sn intermetallic** compds. at the **solder** -substrate interface for the improvement in the wettability of the **Cu** substrate.

for restriction reasons

[redacted]

AN 130:103452 HCA
TI Effect of thermal ageing on (**Sn-Ag**, **Sn-Ag**-Zn)/PtAg, **Cu**/Al2O3 **solder** joints
AU Wei, Y. Y.; Duh, J. G.
CS Department of Materials Science and Engineering, National Tsing Hua University, Hsinchu, Taiwan
SO J. Mater. Sci.: Mater. Electron. (1998), 9(5), 373-381
CODEN: JSMEEV; ISSN: 0957-4522
PB Kluwer Academic Publishers
DT Journal
LA English
AB As-fabricated **solders** of eutectic **Sn-Ag** and ternary **Sn**-3.5% **Ag**-1% Zn alloys are coupled with metalized substrates including PtAg/Al2O3 and **Cu**/Al2O3 to simulate the **solder** joint in microelectronics. The growth mechanism of **intermetallics** and the mech. properties of **solder** joints after thermal ageing (150.degree. and 200.degree.) are evaluated. A 1206 passive device/**solder**/metalization/Al2O3 surface mount technol. (SMT) assembly is employed, and a **Cu** stud is attached on the ceramic substrate assembly to evaluate mech. properties and the fracture morphol. by the pull-off test. Microstructure evolution of the interfacial morphol., elemental and phase distribution are probed with the aid of SEM, electron probe micro-anal. (electron-probe microanal.) and XRD techniques. There are two **intermetallics** (Cu3Sn and Cu6Sn5) formed at the eutectic **Sn-Ag** **solder**/**Cu** metalized layer interface, while only Cu6Sn5 is obsd. in the **Sn**-3.5Ag-1Zn/**Cu** system. However, in the PtAg metalized substrate, only Ag3Sn is present, regardless of which **solders** are employed. Cu6Sn5 and Ag3Sn in the **Sn**-3.5Ag-1Zn system contain 2-5 at.% Zn due to the higher soly. of Zn in both **Cu** and **Ag**. The adhesion strength decreases as the time increases for all **solder** joint systems in the thermal ageing test. The **solder** joint with eutectic **Sn-Ag** alloy exhibits higher fracture load than that with **Sn**-3.5Ag-1Zn alloy. From the fracture surface anal., as the ageing time increases, the fracture takes place from the **solder**/conductor interface toward the inside of the IMC (**intermetallic** compd.).

AN 130:69829 HCA
TI Comparison of mechanical fatigue fracture behavior of eutectic **Sn-Ag solder** with and without Cu6Sn5 **intermetallic** particulate reinforcement
AU Gibson, A. W.; Subramanian, K. N.; Bieler, T. R.
CS Materials Science and Mechanics, Michigan State University, MI, USA
SO J. Adv. Mater. (1998), 30(2), 19-24
CODEN: JADMEK; ISSN: 1070-9789
PB Society for the Advancement of Material and Process Engineering
DT Journal
LA English
AB The isothermal mech. fatigue fracture behavior of noncomposite eutectic **Sn-Ag** and composite eutectic **Sn-Ag solder** contg. 20 vol.% Cu6Sn5 is examd. Single shear lap joints of both **solders** were fabricated using **copper** substrates and subjected to isothermal mech., cantilever bending fatigue at a frequency of 50 Hz. The fracture surfaces of noncomposite eutectic **Sn-Ag solder** joints exhibited ductile, mixed mode (I and II) fracture behavior and step-type fatigue striations that originated at a local region. The fracture surfaces of the composite eutectic **Sn-Ag solder** contg. 20 vol.% Cu6Sn5 exhibited cleavage of the Cu6Sn5 particulate reinforcement and ductile, Mode I fracture of the eutectic matrix with no single origin of initiation corresponding to homogeneous ductile fracture.

AN 130:31621 HCA
TI Thermodynamic prediction of interface phases at **Cu**/**solder** joints
AU Lee, Hyuck Mo; Yoon, Seung Wook; Lee, Byeong-Joo
CS Department of Materials Science & Engineering, Korea Advanced Institute of Science and Technology, Taejon, 305-701, S. Korea
SO J. Electron. Mater. (1998), 27(11), 1161-1166
CODEN: JECMA5; ISSN: 0361-5235
PB Minerals, Metals & Materials Society
DT Journal
LA English
AB A thermodn. method to predict the **intermetallic** compd. which forms 1st at the substrate/**solder** interface during the **soldering** process has been suggested through calcns. of metastable phase equil. between the substrate and the liq. **solder** and by comparison of the driving forces of formation of individual **intermetallic** compd. phases. It has been applied to the interfacial reaction between **Cu** substrate and **Sn**-**Ag**, **Sn**-Zn eutectic **solders**. The prediction from thermodn. calcns. was in good agreement with obsd. exptl. results. The solid-state growth behavior of compd. phases formed at the interface of **Cu**/**Sn**-Zn and **Cu**/**Sn**-**Ag** eutectic **solder** joints was explained and a schematic diffusion path suggested through calcd. ternary phase diagrams.

AN 105:212756 HCA
TI Comparison of structures of gas-**atomized** and of emulsified highly undercooled nickel-**tin alloy** droplets
AU Yamamoto, Michiharu; Wu, Yanzhong; Shiohara, Yuh; Flemings, Merton C.
CS Dep. Mater. Sci. Eng., MIT, Cambridge, MA, 02139, USA
SO Mater. Res. Soc. Symp. Proc. (1986), 58(Rapidly Solidified Alloys Their Mech. Magn. Prop.), 411-14
CODEN: MRSPDH; ISSN: 0272-9172
DT Journal
LA English
AB A comparison was made of microstructures of droplets of hypoeutectic Ni-25 wt.% Sn [94900-11-5] rapidly solidified by (1) gas **atomization** and (2) in a glass emulsifying medium. Cooling rate of the gas-**atomized** particles was 103-106 **K/s** for droplet diams. 20-230 .mu., most of which had a dendritic structure. According to DTA, the same particles, melted and resolidified in a glass medium, showed undercoolings .ltoreq.280 K. The structure was dendritic at low undercoolings and non-dendritic at undercoolings .gtoreq.220 K. The gas-**atomized** particles exhibited little or no undercooling before nucleation. Solidification time of the undercooled emulsified droplets is substantially less than that of gas-**atomized** droplets. The undercooling required to achieve a non-dendritic structure depends on the droplet size.

AN 109:41891 HCA
TI Rapid solidification by optimized gas **atomization**
AU Kaysser, W. A.; Rzesnitzek, K.; Laag, R.; Wachter, J.; Petzow, G.
CS Max-Planck-Inst. Metallforsch., Stuttgart, D-7000/80, Fed. Rep. Ger.
SO Horiz. Powder Metall., Proc. Int. Powder Metall. Conf. Exhib. (1986), Volume 1, 84-8. Editor(s): Kaysser, W. A.; Huppmann, W. J. Publisher: Schmid, Freiburg/Br., Fed. Rep. Ger.
CODEN: 56FXAV
DT Conference
LA English
AB A sharp transition from medium to very fine Sn powders occurred when the Ar **atomization** pressure increased to .gtoreq.80 bar. Cu-7%Sn particles had a finer dendritic structure when water **atomized** (106 **K/s**) than when Ar **atomized** (105 **K/s**),. Water **atomized** Cu-20Sn had a mixed globular/dendritic microstructure, and Cu-35%Sn was entirely .delta. phase. Cu-5.9Ti and Cu-5.7%Zr gas **atomized** microstructures were independent of particle size due to the high d. of equally potent nuclei.

AN 110:61953 HCA
TI **Atomized** powders with reduced microstructure variations
AU Kaysser, W. A.; Rzesnitzek, K.; Petzow, G.
CS Inst. Werkstoffwiss., Max-Planck Inst. Metallforsch., Stuttgart, D-7000, Fed. Rep. Ger.
SO Mod. Dev. Powder Metall. (1988), 20, 79-91
CODEN: MDPDB2; ISSN: 0097-2223
DT Journal
LA English
AB A distinct undercooling was achieved by adding or eliminating heterogeneous nuclei in the melt. The microstructures of fine particles of Cu-**Sn alloys** which were solidified after adding a large no. of artificial nuclei with calcd. cooling rates of 103-106 **K/s** showed fine and homogeneous dendritic microstructures. Elimination of heterogeneous nuclei in the melt before **atomization** resulted in extended undercooling and formation of microstructures with featureless areas. A homogeneous dispersion of fine inert oxide particulates present in the melt was still maintained in the solidified featureless areas.